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CONFERENCE REPORT

on

COTTON INSECT RESEARCH AND CONTROL
MEMPHIS, TENNESSEE
December 2-4, 1951

(Second Memphis Report)

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This is the fifth report to summarize results of Conferences of State and Federal workers concerned with cotton insect research and control in the cotton-growing States East of New Mexico. The conferences were held at:

Stoneville, Mississippi on November 17-19, 1947
Baton Rouge, Louisiana on November 8-10, 1948
Jackson, Mississippi on November 28-30, 1949
Memphis, Tennessee on December 4-6, 1950
Memphis, Tennessee on December 2-4, 1951

These reports bring together results of research and experience during the year concerned in control of cotton insects. The 5 reports indicate much of the progress made during the past five years. Each Conference report, in general, supersedes the report of the previous year but each report contains some information and items not in other reports. These reports are not for general distribution. They are, however, available to entomologists and other research and extension workers, libraries, research agencies, the insecticide industry, and others interested in cotton production.

Results summarized herein should aid preparation of state recommendations issued for cotton insect control for 1952. Although this report was not prepared for California, Arizona, New Mexico, and the western part of Texas, the conferees had the benefit of research and experiences of cotton entomologists in those States.

Contents

COTTON INSECT RESEARCH AND CONTROL

Introduction

Research and extension entomologists and associated technical workers from thirteen cotton-growing states (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia), the United States Department of Agriculture and the National Cotton Council of America, participated in a Conference at the Gayoso Hotel, Memphis, Tennessee on December 2-4, 1951 to formulate a guiding statement for cotton insect control recommendations in 1952 based upon the research and experience of 1951 and previous years. Each section and sentence in this report was carefully considered and unanimously approved by all members of the Conference. The Conferees are listed on pages 41-43. Cultural methods and the use of insecticides for controlling cotton pests are considered in this report.

Cultural control practices cannot be too strongly emphasized. It should be recognized that control of cotton insects by the use of insecticides is really supplemental to the adoption of good farm practices. Cultural control methods include such factors as early fall clean-up before frost where possible on farms where the boll weevil or pink bollworm occur, seed treatment, early planting, fertilization, use of proper cotton varieties, proper land use, and cultivation. Cultural measures used in cotton insect control depend upon which insects are to be controlled and are influenced by climate, soil conditions, fertility, topography, and geographical location.

In addition to recommendations for the use of certain insecticides for control of cotton insects, this report presents information believed to be of value (1) to industry in planning production programs and (2) to State and Federal workers who cooperate with cotton growers in testing insecticides still in an experimental stage. It contains some suggestions as to research needs in developing more effective cotton insect control programs. A general state of plans is included by which extension entomologists will aid in bringing to the attention of growers and all other interested groups the 1952 cotton insect control recommendations for each State. Control recommendations are presented in a general manner and are not specifically fitted to local needs. It is expected that each State, in preparing recommendations for cotton insect control for 1952 will adapt to its own conditions the information given in this summary.

No restrictions are placed on the duplication of this report in whole or in part except in quoting, material should not be removed from the context. If the report is not reprinted in its entirety, no less than a complete section relating to one material, or insect, and supplemental statements referred to therein, should be copied. No portion of this report should be used for advertising purposes.

Policy and Ethics

The chief purpose of the Cotton Insect Conference is to enable State and Federal entomologists to make information readily available to each other which may be useful in further research and extension work in cotton insect control. This exchange of information makes mutual support possible. The obvious purpose of improvement of research and extension work in cotton insect control is to reduce losses caused by insects.

While agreement on major recommendations may be expected, complete standardization is not possible. Details of recommendations must vary with requirements of the region or locality. Such differences are sometimes interpreted as disagreement among entomologists and can be a basis for confusion. Cotton growers should follow the advice of qualified entomologists in their respective States who are familiar with their local problems to avoid this confusion.

It should be recognized that procedures, equipment, and materials that may be effectively used in control of the various insect pests of cotton are now known. This adds to the stability of control recommendations. Research is continued, however, to find new procedures, equipment, or materials which may have advantages over those now in use. In bringing the results of new research to public attention, the impression that a panacea for all problems is being introduced tends to discredit all other work and should be forestalled. It is desirable that results of research should not be reported to the public, or made a basis for recommendations, until they have been made available to other entomologists working in the same field.

In making recommendations for the use of insecticides, entomologists should recognize their responsibility with regard to the hazards to public safety and other interests involved in the use of such materials.

Unfortunately, various so-called boll weevil "remedies" of little or no value, have been put on the market through the years. Although some had slight value, usually most were less effective and more expensive than widely tested standard methods of insect control. Cotton growers are urged not to risk wasting money experimenting with unapproved devices, materials, or mixtures. Many cotton farmers are persuaded by salesmen to spend much money in purchasing mixtures and machines that have little or no value in increasing yields or improving quality of cotton.

Hazards and Precautions in the Use of Insecticides

Development of newer synthetic organic insecticides provides more effective means of controlling insects, but numerous problems have been intensified by these new chemicals such as hazard to man, domestic animals, crops, and beneficial wild life. Most insecticides are poisonous

to animals and man. They should be used with appropriate precautions because of this.

The factor of immediate toxicity of insecticides is of great importance to the user, to livestock, beneficial insects, and plants. There is, in addition, the effect of chronic toxicity due to repeated exposures, of accumulations in soils, and of residues on treated plants and on adjacent crops caused by drift. Everyone concerned with insecticides and their use should be thoroughly familiar with these various hazards. Proper precautions should be taken when formulating, packaging, labeling, and applying these materials.

Precautions for the User

In considering the hazards to man, it is necessary to distinguish between immediate hazards (acute toxicity) and the accumulative effects (chronic toxicity). Man can be poisoned by breathing most insecticides, or by absorbing them through the skin, as well as by swallowing them.

Most solvents used in preparing solutions or emulsions are poisonous. Some are inflammable. Research and experience indicates that new chlorinated organic insecticides are reasonably safe to man and higher animals at strengths normally applied for cotton insect control. In concentrated form, some of the chlorinated hydrocarbon insecticides may cause acute poisoning when they contact the skin or when they are swallowed. Continued contact with, or exposure to, such materials may result in an injurious accumulation of the toxic ingredient in the body. Persons engaged in applying these insecticides should avoid unnecessary exposure to them. It is advisable to wear a respirator with suitable filter pads. Hands should be washed thoroughly before food is handled. After a dusting or spraying operation is complete, and at least once a day when handling or applying insecticides, it is advisable to bathe and change clothes.

Phosphorus compounds such as parathion and tetraethyl pyrophosphate are extremely poisonous materials and must be handled with great care.

It is not practicable to give all precautionary measures here that should be taken when phosphorus compounds are used. Such information is available through basic manufacturers, or the Bureau of Entomology and Plant Quarantine. All users should be thoroughly familiar with precautions and see that they are followed.

An important precaution to observe is the avoidance of breathing wettable powders, dusts, sprays, or vapors. When handling or applying parathion, use a respirator that has been passed by the U. S. Department of Agriculture. A mimeograph circular dated August 24, 1951, was issued by the Bureau of

Entomology and Plant Quarantine under the title "Respiratory Devices for Protection Against Inhalation Hazards of Dusts, Mists, and Low Vapor Concentrations of Certain Insecticides."

Loading and mixing should always be done in the open. Impervious gloves should be worn if it becomes necessary to handle the materials, but it is best to avoid unnecessary contact with insecticide sprays as well as dusts. Concentrated emulsions and wettable powders are especially dangerous. As soon as possible after the use of phosphorous compounds, exposed personnel should bathe and change clothes.

It is advisable to have at hand in the field a change of clothing, soap and water, and a small supply of 1/100-gr. atropine tablets for emergency use, as recommended by competent medical authorities. Quick action is essential in case any symptoms of poisoning appear. Persons directing control operations should assume full responsibility for enforcement of adequate precautions and should have had medical advice as to emergency atropine use.

Spraying or dusting operations should be done under such conditions and in such a manner as to avoid excessive drift to adjacent fields where animals are pastured or where food crops are being grown. No organic phosphate should be applied by aircraft or custom sprayer in such a manner that unprotected persons will be exposed to dust or spray. Care in preventing drift is also essential because certain varieties of plants and kinds of crops may be injured by some insecticides. Spillage of insecticides should be avoided where they might contaminate water used by man or livestock.

Excess dusts or sprays, even in small quantities, should be deeply buried.

Empty containers in which insecticides have been packaged should be burned or otherwise destroyed as soon as empty. Insecticides should always be clearly identified by labels and stored in a place where they are inaccessible to irresponsible persons or domestic animals.

Equipment used for applying weed killers should not be used for applying insecticides because of danger of crop injury.

Residues in Soils

The effect of insecticides on germination, rate of growth, and flavor of crops may be influenced by type of insecticide, formulation used, soil type, kind of plant, and/or concentrations of residues in the soil. Information so far indicates that no immediate hazard to crop is involved when amounts and concentrations recommended for the control of cotton insects are followed. Injury has been demonstrated to several crops by higher

rates of application of some insecticides on certain soil types. Benzene hexachloride may cause off-flavor of some root crops. The possibility that off-flavor may occur in peanuts grown in fields where cotton was previously treated with benzene hexachloride is being investigated.

Safeguarding Beneficial Forms of Life

Insecticides destroy beneficial as well as injurious insects. Some are highly toxic to fish and other forms of aquatic life. It is especially important to use minimum amounts where there would be an unavoidable drift to ponds and streams. Every precaution should be taken to avoid the pollution of streams and farm ponds stocked with fish in disposing of excess spray or dust materials, or when cleaning dusting or spraying equipment.

Preventing Bee Losses

Dusting cotton may cause heavy losses of field bees. Calcium arsenate appears to be the most dangerous insecticide in this respect because field bees may carry it to the hive where it is fed to the developing brood. Organic insecticides employed for cotton insect control, however, do not reach the brood. Toxaphene appears to be less hazardous to use than benzene hexachloride or DDT where bees are working flowers. Chlordane appears to be more toxic to bees than DDT or benzene hexachloride. No information has been obtained about the effect on bees of aldrin and dieldrin.

To hold bee losses to a minimum, the following suggestions are made:

1. Unnecessary dusting or spraying should be avoided by careful scouting and timing.
2. Cotton growers should notify beekeepers before dusting or spraying so that bees can be moved. Beekeepers should contact cotton growers before the cotton insect control season begins and request their cooperation. County agents may serve as clearing houses for such notifications. County agents and cotton growers should be given the exact location of apiaries.
3. Beekeepers should be kept informed of cotton insect infestations and recommendations for their control. This will enable them to locate bee yards in the safest available places and to know where and when insecticide applications are to be made.
4. Dusting or spraying should be done under good atmospheric conditions and care exercised to avoid drift, particularly into bee yards.
5. Other things being equal, the insecticide used should be one least toxic to bees.
6. Cultural control measures should be used to reduce necessity for insecticidal control.

Bee losses can be reduced if better understanding and cooperation can be developed between beekeepers and cotton farmers.

Methods of Applying Insecticides

Dusts

The new organic insecticides are used as toxicants in dust mixtures with carriers such as talcs, pyrophyllite, and clays, or in mixtures with other insecticides. Too much emphasis cannot be placed upon proper formulations.

Progress has been made in the formulation of good quality dusts for use on cotton. Reports of poor results are often due to improper application. Research workers have attributed erratic results and poor control in some instances to inferior dusting qualities of the mixtures. Use of mixtures with excellent dusting qualities is in the interest of insecticide conservation, which is essential in view of the present insecticide supply situation. More information is needed concerning insecticidal formulations to establish criteria for suitable organic insecticide dust mixtures.

Sulfur as a diluent gives dust mixtures certain undesirable physical properties. The supply of sulfur was short in 1951 and it is expected to be even more so in 1952. Sulfur should not be used as a diluent for other insecticides so that available supplies will not be wasted. Where spider mites are a problem, however, at least 40 percent of a good grade of dusting sulfur or appropriate amounts of some other suitable miticide is desirable in the mixture.

Sprays

Several organic insecticides were applied widely in spray form during 1950. Results during the last three years proved that concentrated sprays of organic insecticides will control cotton insects as well as dusts. Sprays have a wide range of usage. They can be applied during most of the daylight hours, even under conditions of relatively strong winds (15 miles per hour). Boll weevil control can be obtained with as little as 1 gallon, or as much as 15 gallons, of spray per acre with the toxicant remaining constant at the recommended rate. Sprays can be applied successfully to cotton for control of all major cotton pests. Most of the new organic insecticides can be made into emulsifiable concentrates, which with the addition of water, give emulsions suitable for application. Slight foliage burning has been noted in some instances when the emulsifiable concentrate was poorly formulated, or when the emulsion was improperly applied, or when the spray was poorly distributed.

Most oil solutions of insecticides tested caused foliage injury. Tests of experimental oils indicate that the viscosity and volatility of the oil and its aromatic content are the main factors involved in the undesirable foliage reaction.

Solvents which will dissolve the toxicant with a relatively low boiling range and aromatic content appear to be most desirable for use in emulsifiable concentrates. Emulsifiers and solvents should be tested for toxicity to the cotton plant, and their general suitability determined, before they are used in formulations.

In general, the mass median diameter of the spray droplets should range from 100 to 300 microns. Manufacturers' recommendations should be followed in regard to pressure for specific nozzle size to insure a proper spray pattern.

For treatment of seedling cotton with ground equipment in most areas, it is suggested that one nozzle per row be used to apply the spray, and as the cotton increases in size, the number of nozzles per row be increased up to three to obtain full coverage. If nozzles are kept at least 10 inches from the plant, better coverage will be obtained and danger of leaf burn minimized.

For use in ground equipment, it is essential that spray concentrates be diluted immediately prior to use with not to exceed an equal volume of water, and the diluted emulsion then added to the required volume of water. Some type of agitation is essential during the spray operation to insure a uniform emulsion.

It is recommended that the spray boom on ground equipment be located behind the operator as a safety measure.

For airplane spray application, it is suggested that from 1 to 2 gallons of spray containing the recommended amount of toxicant be applied per acre. Some method of flagging or marking of swaths should be used to get best results in airplane spraying.

For stability in storage and to prevent breakdown of the formulation when metal containers are used, the containers should be lined with some material that will not react with or cause deterioration of the concentrate. It is undesirable to reuse metal containers for the packaging of emulsion concentrates. Used containers, especially 30- and 50-gallon drums, often have breaks in the lining. These are hard or impossible to detect and will cause a breakdown of the formulation by permitting it to come in contact with the metal. Containers sometimes become contaminated with 2,4-D or 2,4,5,-T on farms. Such contamination cannot always be detected and reuse of contaminated containers might prove very hazardous to the processor as well as to the farmer.

It is desirable that insecticides be prepared in such a way that they may be combined with each other to form a satisfactory emulsion. It is suggested that the manufacturers prepare formulations in even multiples of the amounts of insecticide recommended per acre, whenever possible. The pounds per gallon of each insecticide in the concentrate should be shown on the label.

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Insecticides

Experimental data and results of field tests presented at the Conference indicated that no particular insecticide gave results outstandingly superior to those of any other recommended insecticide or mixtures of materials when they were used at the dosage, time, and frequency recommended by official entomologists. These are most important factors in the effective use of insecticides for cotton insect control.

Aldrin

Aldrin was used widely for cotton insect control during 1950 and 1951. It will control the boll weevil, thrips, the cotton fleahopper, the tarnished plant bug, the rapid plant bug, grasshoppers, and newly hatched cotton leafworms in most cases. It will not control the bollworm, the yellow-striped armyworm, certain species of cutworms, the cotton aphid, or spider mites. Aldrin may increase spider mites and mixtures of aldrin and DDT may increase aphids. For boll weevils, aldrin should be applied at the rate of 0.25 to 0.75 pound per acre. It is effective as a dust or spray.

Aldrin is toxic by skin absorption, by inhalation, and by ingestion. It is recommended for use on cotton only where persons applying it are fully aware of the hazards and will follow the precautions prescribed by the manufacturers.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Benzene Hexachloride

Benzene hexachloride will control the boll weevil, the cotton aphid, the tarnished plant bug, the rapid plant bug, the cotton leafworm, thrips, the southern green stink bug, the garden webworm, the fall armyworm, the cotton fleahopper, and grasshoppers. It will not control the bollworm, the yellow-striped armyworm, some species of cutworms, the pink bollworm, the salt-marsh caterpillar, and spider mites.

Benzene hexachloride alone thus cannot be successfully employed for over-all cotton insect control. Benzene hexachloride may increase spider mites.

In dusts, benzene hexachloride at approximately 0.3 pound of the gamma isomer per acre (example: 10 pounds of benzene hexachloride dust containing 3 percent of the gamma isomer) is the minimum rate that consistently gives satisfactory control of all cotton insects for which it is recommended. The most common commercial dust formulations containing benzene hexachloride used by cotton growers contain 3 percent of the gamma isomer and 5 percent of DDT, with or without sulfur.

A spray formulation containing sufficient technical benzene hexachloride to give 0.3 to 0.4 pound of the gamma isomer plus 0.5 pound of technical DDT per acre has given satisfactory control of the boll weevil and the bollworm. Proper formulation of the emulsion concentrate is necessary to prevent foliage or plant injury.

Benzene hexachloride is toxic to warm-blooded animals. It may enter the body through absorption, inhalation, or ingestion. Proper precautions should therefore be observed in its use.

Grain sorghum, barley, cowpeas, and some other crops are adversely affected by benzene hexachloride. Further research is needed concerning the accumulation of this insecticide in the soil following applications to cotton and resultant effects of residues of the insecticide on other crops. It is inadvisable to use benzene hexachloride for cotton insect control where the land will later be planted to these crops until more is known regarding the danger of possible off-flavor in peanuts, irish potatoes, and some other crops.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Calcium Arsenate

Calcium arsenate is an economical and effective insecticide with excellent dusting qualities for control of the boll weevil and the cotton leafworm. It is used at the rate of 7 to 10 pounds per acre for boll weevil and cotton leafworm control. Twelve to 15 pounds per acre will give fair control of bollworms if applications are properly timed. It is usually used undiluted against the above-mentioned insects. An increase in aphid population often results when used without an aphidicide. Alternate applications of calcium arsenate and formulations containing chemicals that will also control aphids have given excellent results in some areas.

Lime-free calcium arsenate is compatible with organic insecticides. When this calcium arsenate is used with parathion (see precautions under Parathion, p. 16), the boll weevil, the cotton aphid, and spider mites may be effectively controlled. When lime-free calcium arsenate is combined with 5 percent of DDT and 1 percent of parathion, effective control of the boll weevils, the bollworm, the cotton aphid, and spider mites are obtained. Lime-free calcium arsenate in combination with these materials should be applied at the rate of 10 to 12 pounds per acre.

Calcium arsenate is injurious to some crops, especially legumes and oats in certain light sandy soils. It should not be used for cotton insect control in fields where rice may be planted. Drifting of the dust may injure other crops. Precautions should be taken to avoid drift that might cause bee losses. Calcium arsenate is poisonous and should be handled carefully. Livestock should be kept out of dusted fields. Care should be taken to avoid drift onto pastures, especially when applications are made by airplane.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Chlordane

Chlordane will control the boll weevil, the cotton fleahopper, the tarnished plant bug, the rapid plant bug, grasshoppers, sand wireworms, and thrips. It will not control the bollworm, the yellow-striped armyworm, the cotton aphid, the pink bollworm, or spider mites. Although it kills a high percentage of boll weevils in squares and bolls, the practical benefit derived therefrom has not been demonstrated.

For the insects against which chlordane is effective, from 0.5 to 1.5 pounds of technical material per acre is required.

For over-all cotton insect control, chlordane should always be formulated with DDT. The rate of application should be such that from 1 to 1.5 pounds of technical chlordane and from 0.5 to 0.75 pound of technical DDT per acre will be applied.

The dust formulation generally recommended should contain 10 percent of chlordane plus 5 percent of DDT. This should be applied at the rate of 10 to 15 pounds per acre. Sprays should contain 2 parts of chlordane to 1 part of DDT.

These formulations have given excellent results in some areas, erratic in others.

The cotton aphid and spider mites may increase to damaging proportions following applications of chlordane-DDT sprays and dusts. Careful inspections for these two pests should be made at weekly intervals after the application of chlordane-DDT formulations, If an increase of either species is observed, appropriate measures should be taken to control them as outlined under the respective pests.

Chlordane is more toxic to higher animals than DDT. Operators should avoid breathing the dust or mist. Contamination of food and feed crops around cotton fields should be avoided.

There have been little or no ill effects on plants from accumulations of chlordane in soils when this material has been applied properly.

See Hazards and Precautions in the Use of Insecticides, p. 4.

DDT

DDT will effectively control the bollworm, the pink bollworm, the fall armyworm, the tarnished plant bug, some species of stink bugs, the rapid plant bug, the cotton fleahopper, and thrips. Unsatisfactory results have been reported when the temperature exceeded 90° F. in some instances. It will also control certain species of cutworms and to a lesser extent the yellow-striped armyworm. It will not control the boll weevil, the cotton leafworm, spider mites, the cotton aphid, and grasshoppers.

As a dust on cotton, DDT is ordinarily used at concentrations of 5 to 10 percent. It is used either alone or in combination with other

insecticides and miticides, and at rates of 10 to 20 pounds per acre. At least 15 pounds per acre of 10 percent DDT should be applied for pink bollworm control.

Sprays and dusts containing DDT are about equal in effectiveness against cotton pests. Thorough coverage of the plant and proper timing of applications are more important than the type of formulation used.

Aphid and mite populations may increase until severe injury occurs where DDT is used unless an aphidicide and a miticide are included in the formulation.

DDT is toxic to certain plants such as cucurbits. Its toxicity persists and accumulates in the soil. It should, therefore, be used only in the minimum amounts recommended for cotton insect control, especially on light sandy soils. Contamination of adjacent crops from drift should be avoided.

DDT is highly toxic to fish and amphibians, and precautions should be taken to avoid the possibility of stream pollution.

Acute toxicity of DDT to man and animals is rather low compared with inorganic insecticides now used on cotton. When DDT is repeatedly ingested or brought into contact with the skin, however, it may be absorbed and stored in the fatty tissues. Injury to liver may also result. Unnecessary exposure of operators should be avoided.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Dieldrin

Dieldrin was used experimentally for cotton insect control in many locations throughout the Cotton Belt in 1950 and 1951. It was recommended for cotton insect control in several states in 1951. It is effective against the boll weevil when applied at the rate of 0.15 to 0.5 pound per acre; against thrips, cotton fleahopper, tarnished plant bug, rapid plant bug, fall armyworm, grasshoppers, and variegated cutworm when applied at dosages of 0.05 to 0.15 pound per acre; against garden webworms at 0.25 pound per acre; against heavy infestations of pale-sided and granulate cutworms and yellow-striped armyworm at 0.375 to 0.5 pound per acre. It is not effective at low dosages for bollworm control. DDT should be added when control of this insect is necessary. Dieldrin may increase spider mites and a mixture of dieldrin and DDT may increase aphids. Dieldrin will kill newly hatched cotton leafworms at dosages effective against the boll weevil. It is effective either as a dust or spray.

Dieldrin is toxic by skin absorption, by inhalation, and by ingestion. It is recommended for use on cotton only where persons applying it will follow the precautions prescribed by the manufacturers.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Heptachlor

Heptachlor was used experimentally for cotton insect control in many locations throughout the Cotton Belt in 1951. It was effective in controlling the boll weevil when applied at the rate of 0.25 to 0.75 pound of technical material per acre in either dust or spray form. It did not control the bollworm and therefore should be mixed with DDT at the recommended rates when it is used for mid-season or late-season boll weevil control. Field tests indicate that heptachlor is effective against thrips at 0.25 pound per acre, against cutworms at 1 pound per acre, and against garden webworms at 0.5 pound per acre.

Heptachlor did not control the bollworm, the yellow-striped armyworm, the cotton leafworm, the cotton aphid, or spider mite. Heptachlor may increase spider mites and a mixture of heptachlor and DDT may increase aphids.

Heptachlor is more toxic to higher animals than chlordane. Operators should avoid breathing dusts and avoid unnecessary contact with sprays containing this material. Information is limited regarding the effect of repeated or prolonged exposure to heptachlor or the possible ill effects on plants from accumulations of it in soils.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Lindane

Lindane, the essentially pure gamma isomer of benzene hexachloride, may be substituted on an equivalent weight basis for the gamma isomer of benzene hexachloride in formulations of insecticides used on cotton insects.

Lindane is toxic to warm-blooded animals. It may enter the body through absorption, inhalation, or ingestion. Proper precautions should therefore be observed in its use.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Methoxychlor

Dusts containing 10 percent of methoxychlor controlled the cotton leafworm, but lower concentrations gave poor control.

Methoxychlor gave slightly better pink bollworm control than DDT, but a heavy build-up of aphids usually followed its use and it failed to control bollworms. It is not being generally used for pink bollworm control for these reasons.

Methoxychlor is less effective than the insecticides now recommended for the control of the boll weevil, the bollworm, the cotton aphid, the garden webworm, spider mites, and stink bugs.

Methoxychlor is less toxic than DDT to warm-blooded animals and it is less likely to be stored in the fat or excreted in the milk.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Nicotine

Two percent of nicotine in alternate applications of calcium arsenate will usually prevent a cotton aphid build-up, if properly applied (the period between nicotine applications should not exceed 8 to 10 days).

Either 2 or 3 percent of nicotine in a suitable carrier can be used to knock out heavy aphid infestations. At least 0.2 pound per acre of free-nicotine equivalent should be applied. The source may be either nicotine sulfate or a fixed nicotine in dust form.

Applications of nicotine dust to knock out heavy aphid infestations should be applied when the air is calm and preferably when there is no dew on the plants. Complete coverage is essential.

Nicotine is highly toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Octamethyl Pyrophosphoramide

This systemic poison is in preliminary stages of investigation and not recommended.

Octamethyl pyrophosphoramide was translocated by cotton plants in laboratory tests when it was applied to soils in which plants were growing. A single soil application of 4 to 8 pounds per acre of the technical compound caused the plants to remain toxic to cotton aphids and spider mites for several months. Lower dosages were ineffective. Spray application to foliage of 1 pound of the compound per acre gave aphid and mite protection for 2 to 4 weeks. Cotton seedlings grown from seed treated with 1 pound of octamethyl pyrophosphoramide per 100 pounds of seed were toxic to aphids and mites for 6 weeks. Higher dosages reduced seed germination and otherwise adversely affected the plant. Octamethyl pyrophosphoramide was ineffective against the boll weevil, the bollworm, the cotton leafworm, the cotton fleahopper, thrips, and a number of other cotton insects. In field tests conducted during 1951 octamethyl pyrophosphoramide applied in the conventional foliage spray at a rate of 0.5 to 1.0 pound per acre gave excellent control of spider mites.

Octamethyl pyrophosphoramide is an extremely dangerous poison to man and other animals. In handling it, the same precautions as indicated for parathion should be followed. Until investigations disclose that this material does not persist, cottonseed meal or other cottonseed products from treated plants should not be fed to livestock.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Parathion

Parathion will control the cotton aphid, spider mites, the garden webworm, and the cotton leafworm. It may be used as a 1-percent dust alone or in combination with other insecticides. It gives very little control of the boll weevil, the fall armyworm, the variegated cutworm, the bollworm, and the pink bollworm. Bollworm infestations sometimes increase following applications of parathion.

Parathion is an extremely dangerous poison. It is recommended for restricted use in some states where qualified personnel are in a position to assume full responsibility and to enforce proper precautions as prescribed by the manufacturers.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Rotenone

One percent of rotenone in calcium arsenate at each application made against the boll weevil has given satisfactory control of the cotton aphid.

Sulfur

Sulfur has been widely used on cotton for control of certain species of spider mites and the cotton fleahopper, when used in dust mixtures. It sometimes has a repressive effect upon aphid populations in some areas. Where spider mites are likely to be a serious problem, 40 percent of sulfur or an appropriate amount of other suitable miticide should be included in organic insecticide dusts to prevent the development of damaging mite infestations. The supply of sulfur is very short for 1952 and it should not be used as a diluent for other insecticides.

Systox

Field and greenhouse tests over a two year period have shown this material to be effective against the cotton aphid and spider mites as either sprays applied to foliage or as a systemic applied to soil. The use of 0.5 milligram of technical material per pound of soil has given protection to cotton for 30 days against these pests in the greenhouse. In the field, 0.2 pound of technical material per acre applied to the soil gave protection for 30 days against aphids.

Cotton leafworms, half-grown and larger were controlled by spraying cotton foliage with 0.5 to 0.75 pound of systox per acre. Field tests conducted in 1951 indicate that systox may increase the effectiveness of toxaphene against the bollworm when used at the rate of 0.15 pound or more of systox to 2 pounds or more of toxaphene per acre.

Systox will not control the boll weevil, bollworm, thrips, or grasshoppers. It does not appear effective when used as a systemic applied

as a seed treatment at rates of up to 1 pound of technical material per 100 pounds of cotton seed.

Systox is an extremely dangerous poison to man and other animals. In handling it the same precautions as indicated for parathion should be followed. Until investigations disclose that this material does not persist, cottonseed meal or other cottonseed products from treated plants should not be fed to livestock.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Tetraethyl Pyrophosphate (TEPP)

Tetraethyl phrophosphate, commonly called "TEPP," is highly effective as a spray against the cotton fleahopper, the cotton aphid, and spider mites when used on dry plants at proper intervals. Experiments indicate that applications containing one-half pint of 40 percent tetraethyl pyrophosphate, or its equivalent, per acre will control heavy populations of these pests effectively.

Tetraethyl pyrophosphate is an extremely dangerous poison. It is recommended for use on cotton only where a qualified person is in a position to assume full responsibility and to enforce proper precautions as prescribed by the manufacturers. This chemical deteriorates very rapidly when exposed to moisture or moist air and is incompatible with alkaline materials. It should be applied immediately after mixing with water. Residual toxicity of the chemical is very short.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Toxaphene

Toxaphene will control the boll weevil, fall armyworm, tarnished plant bug, rapid plant bug, cotton leafworm, cutworms, and grasshoppers when applied at the rate of 2 to 3 pounds of the technical material per acre. It is slightly less effective against the bollworm and yellow-striped armyworm. It will also control the cotton fleahopper and thrips when applied at the rate of 0.75 to 1 pound of the technical material per acre. Properly applied dusts and sprays are about equally effective in most areas.

Bollworm control was improved where DDT was incorporated in the toxaphene spray mixture at the rate of 0.25 to 1.0 pound per acre. Toxaphene alone will not give satisfactory control of the pink bollworm.

Satisfactory suppression of the cotton aphid resulted where toxaphene was used throughout the season. It will not control heavy aphid infestations, nor will it control spider mites, and its use may result in their increase. In some areas it is therefore recommended that dusts contain at least 40 percent of sulfur, or an appropriate amount of some suitable miticide.

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No economic injury to cotton has been reported from the use of toxaphene. This material can be handled with relative safety to the operator if proper precautions are taken. Toxaphene is toxic to livestock and pountry, and is very toxic to fish.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Promising New Insecticides Tested in 1951

Compound 269

Compound 269 is a stereoisomer of dieldrin and chemically designated as 1,2,3,4, 10,10-hexachloride-6, 7-epoxy-1,4,4a, 5,6,7,8,8a-octahydro-1, 4,5,8-endo-endo-dimethanonaphthalene. In limited field tests when applied to cotton as dust or sprays at 0.2 to 0.5 pound per acre, it was effective against the boll weevil, bollworm, tobacco budworm, variegated cutworm, fall armyworm, and tarnished plant bug. It was found to be toxic to a wide range of lepidopterous larvae and at 0.2 pound per acre gave bollworm control equal to 0.5 pound of DDT. In late-season tests it gave excellent control of the boll weevil and bollworms. Compound 269 did not control spider mites and was only moderately effective against the yellow-striped armyworm. Aphids did not build up to damaging numbers following its use. Compound 269 is not recommended for general cotton insect control because of limited tests, but it should be widely tested in large-scale experiments in 1952. Mammalian toxicity data available indicate this compound to be highly toxic. It should be handled with extreme care.

See Hazards and Precautions in the Use of Insecticides, p. 4.

EPN (O-ethyl O-p-nitrophenyl benzenethiophosphonate)

Laboratory tests in 1950 indicated that EPN might be useful in control of several cotton insects and mites. In field tests during 1951 EPN at the rate of 0.3 pound per acre of the technical product failed to give satisfactory control of the boll weevil, bollworms, cutworms, and some species of spider mites. It was highly effective at that rate for control of the yellow-striped armyworm.

EPN at the rate of 1 pound per acre showed promise for pink bollworm control. Control of bollworms was obtained with applications of 1.25 pounds of the technical material per acre.

Further tests are needed to determine its place in the control of cotton pests.

Mammalian toxicity of EPN is less than that of parathion but it is nevertheless high in relation to most poisons used in cotton insect control. Therefore, it should be handled with precaution.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Compound 711

Compound 711 is a stereoisomer of aldrin and chemically designated as 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4,5, 8-endo-endo-dimethanonaphthalene. Compound 711 gave considerable control of the boll weevil at 0.2 pound per acre in limited field tests. It was relatively ineffective against the bollworm, fall armyworm, and yellow-striped armyworm. Preliminary investigations indicate a rather high acute oral toxicity to mammals. Conclusions on the effectiveness of this chemical cannot be reached on the basis of present results.

See Hazards and Precautions in the Use of Insecticides, p. 4.

The following new insecticides were found to be promising enough during 1951 to justify carrying into field tests during 1952 for further evaluation. The following statements are based entirely on results obtained from field cage and laboratory experiments.

Methyl Parathion (Methyl ester of parathion)

This compound appears very promising against the boll weevil at dosages of between one-fourth and one-half of a pound of the technical material per acre. Within this range it would be highly effective against the cotton aphid and spider mites. It is highly effective against the cotton leafworm at dosages as low as one-twentieth of a pound per acre. It does not appear especially promising against the bollworm although some bollworms are killed by it when applied at the rate of one-fourth to one-half pound per acre.

Metacide

This product is a mixture containing 6.2% of parathion, 24.5% of methyl ester of parathion, 2.7% of related organic phosphates, and 66.6% of a special emulsifer, Thiosolve 8139. It showed considerable promise against the boll weevil at dosages of between three-tenths and one-half of a pound of total active ingredients per acre and was highly effective against the cotton aphid and spider mites within this range. It was also highly effective against the cotton leafworm at a dosage as low as 0.075 pound of total active ingredients per acre. It does not appear to be highly effective against the bollworm.

Malathon, also called Compound 4049

This compound (O,O-dimethyl dithiophosphate of diethyl mercaptosuccinate)

appears promising for the control of boll weevil, spider mites, and the cotton aphid within the range of one to two pounds of the technical material per acre. It is not effective against the bollworm.

Compound 1795

Compound 1795, a derivative of the chemical 2,3,3a,4,5,6,7,7a,8,8-decachloro-3a,4,7,7a-tetrahydro-4,7-methanoidene-1-one. Promising results were secured against the boll weevil when approximately two pounds of this chemical were applied per acre. Results against the bollworm were erratic.

Compound Q-129

1,2,4,5,6, 7-hexachloro-1,1-dimethoxy-4, 7-methano-3a,4,7,7a-tetrahydroindane. In limited tests with this compound, it appeared promising against the boll weevil when applied at approximately two pounds of the technical material per acre. Erratic results were obtained against the bollworm.

B. F. Goodrich Insecticide 3960 - X14

A mixture of chlorinated terpene isomers. This compound reacted similarly to toxaphene when applied at comparable dosages. It is effective against the boll weevil, the bollworm, and the cotton leafworm.

Dimethyl potasan

The dimethoxy thiophosphoric acid ester of 7-hydroxy-4-methyl coumarin. This compound showed promise against the boll weevil at dosages of from one-fourth to one-half pound of the technical material per acre. It appears that the cotton aphid and spider mites would also be controlled by dosages within this range. Bollworm control, however, might be expected to be inadequate with this range of dosages.

Cultural Practices Aid in the Control of Cotton Insects

Certain cultural practices reduce cotton losses from insect pests. These practices often reduce, and may eliminate, the need for insecticides. Such practices should be encouraged. This is especially important when insecticides are in short supply. Several cultural practices can be used by every cotton grower. Others are only applicable to certain areas and conditions. In addition to following these practices, growers should continue to make careful observations for insects and apply insecticides when needed.

Planting

Reasonably early planting of all cotton during a short period within an area enables the crop to produce maximum growth and fruit before insects multiply and spread from field to field. This also makes earlier stalk destruction possible.

Varieties

Prolific varieties of cotton that fruit early and mature quickly may set a crop before the boll weevil and other insects become numerous. This is especially true when other cultural control practices are followed.

Soil Improvement

Rapidly-growing cotton in rich soil can stand more injury from insects without material reduction of yield than cotton growing in poor soil. Fertilization, rotation of crops, and plowing under of green manure, tend to off-set insect losses for this reason. It is recommended that winter cover crops be planted to improve the soil and prevent erosion.

Other Host Crops of Cotton Pests

Cotton fields should be located as far as is practicable from other host plants of cotton insects. Thrips breed in onions, potatoes, carrots, and some other crops. They move in great numbers into adjacent or interplanted cotton later. Garden webworms and variegated cutworms and Lygus bugs may migrate to cotton from alfalfa. The cotton flea-hopper migrates to cotton from croton and other weeds.

Hibernation Areas

Boll weevils hibernate in well-drained, protected areas in and near cotton fields during the winter. Spider mites hibernate in low-growing perennials in or near fields. Clean cultivation reduces weevil hibernation quarters. Small patches of weeds near fields, along turnrows and fences, or around stumps and scattered weeds in cultivated fields or pastures can be destroyed with small cost. Such practices are more effective where the cotton acreages are in sizeable blocks rather than in small patches. General burning of ground cover in woods is not recommended.

Early Stalk Destruction

The destruction or killing of cotton plants as early as possible before the first killing frost, either by mechanical or chemical methods forces

boll weevils into starvation before they go into winter quarters. Early stalk destruction, especially over community- or county-wide areas, has resulted in greatly reducing the boll weevil problem in the Lower Rio Grande Valley and other parts of Texas. This practice is also recognized as important in pink bollworm control in most areas. Plowing under the crop residue as deeply as possible after the stalks are cut also will reduce the pink bollworm survival. Modern mechanically-operated stalk cutters and shredders facilitate early stalk destruction and complete coverage of crop residues.

Legumes in Relation to Cotton Insect Control

Soil-building and soil-conserving leguminous crops are generally fundamental in a cotton-growing program. It is further recognized that a number of insects that attack legumes later transfer to cotton, thereby increasing the cotton insect problems. This situation may have a tendency to discourage the use of legumes, but this should not be so. Entomologists should give serious consideration to insect control for the protection of both legumes and cotton.

Bug-Catching Machines

Bug-catching machines are not recommended as a means of controlling cotton insects.

Chemical Defoliation as an Aid to Insect Control

Defoliation of cotton with chemicals has a direct relation to cotton insect control. Defoliation has been found to cause boll weevils to leave treated fields almost immediately. It also reduces the percentage of locks infested by weevils. Where cotton has been defoliated a much smaller number of weevils have been found the next spring. Damage to open cotton by heavy aphid populations and by late cotton leafworm infestations has been prevented by chemical defoliation.

Proper defoliation checks the growth of the cotton plant and accelerates the opening of bolls. The crop may be harvested earlier, thereby permitting earlier destruction of the stalks, an important aid in boll weevil and pink bollworm control.

Defoliants should not be applied until the last bolls expected to make cotton are at least 25 days old for best results. Satisfactory defoliation cannot be expected if excessive soil moisture, high fertility, or insufficient insect control cause plants to be highly vegetative. Second growth also has been found very difficult to remove with chemical defoliants.

Detailed guides for use of different defoliants, and rates and methods of application, will be found in the Annual Report of Progress from the Cotton Defoliation Conference, issued by the National Cotton Council of

America, Memphis, Tenn. This report contains information concerning the influence of plant activity, stage of maturity, and effects of environment on efficiency of the process. The report gives details relative to the various needs and benefits. It explains how loss in yield and quality of products may be caused by improper timing of the applications.

These guides to the use of the defoliation process are based on broad ecological areas, rather than on State boundaries. An individual should consult local agricultural specialists if he has any doubt concerning proper methods, time of application, or actual need for the process.

Cotton Insects

Boll Weevil

The boll weevil, Anthonomus grandis Boh., may be controlled effectively with benzene hexachloride, calcium arsenate, toxaphene, aldrin, heptachlor, or dieldrin. Benzene hexachloride should be applied at a rate of not less than 0.3 pound of the gamma isomer per acre, calcium arsenate at 7 to 10 pounds per acre, toxaphene at 2 to 3 pounds of the technical material per acre, aldrin at 0.25 to 0.75 pound of the technical material per acre, heptachlor at 0.25 to 0.75 pound of the technical material per acre, and dieldrin at 0.15 to 0.5 pound of the technical material per acre. When these insecticides are used for boll weevil control under field conditions, other insect problems have to be considered. Infestations of the cotton aphid, bollworm and/or spider mites may develop when some of these insecticides are used alone.

The following dusts have been approved for use in areas where recommended:

1. Benzene hexachloride to give 3 percent of the gamma isomer in the finished dust plus 5 percent of DDT (sometimes referred to as "3-5-0").
2. Calcium arsenate applied alternately with calcium arsenate plus 2 percent of nicotine.
3. Calcium arsenate applied alternately with mixture of benzene hexachloride (3 percent gamma isomer) and 5 percent of DDT.
4. Lime-free calcium arsenate plus 1 percent of parathion.
5. Lime-free calcium arsenate plus 1 percent of parathion and 5 percent of DDT.
6. Toxaphene 20 percent.
7. Aldrin 2.5 percent.
8. Aldrin 2.5 percent plus 5 percent of DDT.
9. Heptachlor 2.5 percent.
10. Heptachlor 2.5 percent plus 5 percent of DDT.
11. Dieldrin 1.5 or 2.5 percent
12. Dieldrin 1.5 or 2.5 percent plus 5 percent of DDT.

13. Chlordane 10 percent plus 5 percent of DDT. (This mixture is recommended only in areas where it has given good control. It has given erratic results in some areas, perhaps because of high temperatures and humidity.)

In areas where spider mites are a problem, dust formulations of organic insecticides should contain sulfur or some other suitable miticide. Where DDT is added to any of the above mixtures it is for bollworm control.

The following treatments with sprays made from emulsion concentrates have given favorable results and are approved where recommended:

1. Toxaphene at the rate of 2 to 3 pounds of the technical material per acre.
2. Toxaphene and DDT in the ratio of 2 to 1 applied at the rate of 2 to 3 pounds of technical toxaphene per acre.
3. A mixture to give 0.3 to 0.5 pound of the gamma isomer of benzene hexachloride and 0.5 pound or more of technical DDT per acre.
4. Aldrin at the rate of 0.25 to 0.75 pound of the technical material per acre.
5. A mixture to give 0.25 to 0.75 pound of technical aldrin and 0.5 pound or more of technical DDT per acre.
6. Heptachlor at the rate of 0.25 to 0.75 pound per acre.
7. Heptachlor at the rate of 0.25 to 0.75 pound per acre plus 0.5 pound or more of the technical DDT per acre.
8. Dieldrin at the rate of 0.15 to 0.5 pound of technical material per acre.
9. A mixture to give 0.15 to 0.5 pound of technical dieldrin and 0.5 pound or more of technical DDT per acre.
10. In areas where it has proved satisfactory and where it is recommended, a mixture of 1 pound of technical chlordane and 0.5 pound or more of technical DDT per acre may be used.

Measures should be applied for boll weevil control when definite need is indicated. Except where early season control measures are practiced, insecticides should be applied at intervals of 4 to 5 days until the infestation is brought under control. Fields should be inspected weekly thereafter and applications made when necessary.

Bollworms

At least four species of lepidopterous larvae damage cotton bolls. The most important are the bollworm, Heliothis armigera (Hbn.) and the tobacco budworm, H. virescens (F.). The tobacco budworm is the predominant species in many collections of bollworms from cotton, particularly in the eastern part of the Cotton Belt. The yellow-striped

armyworm, Prodenia ornithogalli Guen., and the fall armyworm, Laphygma frugiperda (A. & S.) also cause boll injury sometimes.

It is a difficult task to control this group of insects sometimes and many erratic results have been reported. Factors which contribute to their abundance are complex and none too well known. The widespread use of certain of the organic insecticides has often resulted in greatly increased bollworm damage, presumably as a result of killing off the natural enemies. Changing farm practices due to diversification and mechanization may have resulted in conditions more favorable for the normal increase of these insects.

Effective bollworm control depends on the thorough and timely use of properly formulated insecticides. Frequent field inspections to determine the presence of eggs and young larvae during the main fruiting period of cotton in any given field are essential. It is too late for effective control after the larvae have already entered the squares and bolls.

The most effective insecticide for bollworm control is DDT. For heavy bollworm infestations it should be applied at the rate of 1.0 to 1.5 pounds of the technical material per acre in a 10 percent dust or concentrated spray. DDT may be used in mixtures with other insecticides where other insects as well as bollworms require control. It is compatible with lime-free calcium arsenate, but not with regular calcium arsenate. Bollworms usually are controlled where 0.5 pound or more of DDT per acre is applied with BHC, aldrin, dieldrin, or heptachlor in the regular schedule for boll weevil control.

Toxaphene, at the rate of 2 to 4 pounds per acre, is the next most effective insecticide against bollworms. This may be applied as a 20 percent dust or as a spray. The addition of DDT to toxaphene dust or spray greatly improves the effectiveness of this insecticide for bollworm control.

Calcium arsenate and cryolite dusts are less effective.

In areas where spider mites are a problem, dust mixtures containing organic insecticides used for the control of bollworms should include 40 percent of sulfur or an appropriate amount of some other suitable miticide.

Cotton Aphid

Heavy infestations of the cotton aphid, Aphis gossypii Glov., often occur on cotton following the use of certain insecticides. Infestations also may be severe on seedling cotton where no insecticides have been applied.

The following treatments, when used for other cotton insect control, will usually prevent an aphid build-up:

1. A mixture containing 3 percent of the gamma isomer of benzene hexachloride and 5 percent of DDT in every application at the rate of 10 to 12 pounds per acre.

2. A mixture containing 3 percent of the gamma isomer of benzene hexachloride and 5 percent of DDT at the rate of 10 to 12 pounds per acre in alternate applications with calcium arsenate.
3. Nicotine 2 percent in regular calcium arsenate at the rate of 10 to 12 pounds per acre alternated with calcium arsenate alone.
4. Parathion 1 percent in lime-free calcium arsenate dust, or 1 percent in dust or 0.1 pound per acre in spray added to aldrin plus DDT, dieldrin plus DDT, heptachlor plus DDT, or toxaphene plus DDT will effectively control the cotton aphid when any of these mixtures are used at the recommended rate for boll weevil concontrol. However, parathion should be used only by those who are qualified to handle such dangerous materials.
5. Toxaphene at the rate of 2 to 3 pounds of the technical material per acre in every application (where toxaphene is not formulated with DDT).

When heavy infestations of the cotton aphid occur and the need for rapid kill is indicated, the following treatments are effective:

1. Benzene hexachloride applied to give 0.5 pound of the gamma isomer or an equivalent amount of lindane per acre.
2. Parathion applied either as a dust or spray at a rate of 0.1 to 0.25 pound per acre of technical material.
3. Nicotine 3 percent in hydrated lime applied at the rate of 10 to 15 pounds per acre.
4. Forty percent tetraethyl pyrophosphate applied at the rate of one-half pint, or its equivalent, per acre. The effectiveness of this material is of short duration.

Cotton Fleahopper

The cotton fleahopper, Psallus seriatus (Reut.), can be controlled with the following dusts applied at the rate of 10 pounds per acre: DDT 5 percent, toxaphene 10 percent, dieldrin 1.5 percent, aldrin 2.5 percent, heptachlor 2.5 percent, benzene hexachloride (gamma isomer 1 percent), and chlordane 2 percent. When spider mites are likely to be a problem, 40 percent or more of sulfur or an appropriate amount of some other suitable miticide should be added to organic insecticide formulations.

The following materials applied as low-gallonage sprays at the rates indicated per acre will give good control of the cotton fleahopper; 0.5 pound of DDT, 1 pound of toxaphene, 0.5 pound of toxaphene plus 0.25 pound of DDT, 0.1 pound of dieldrin, 0.2 pound of aldrin, 0.2 pound of heptachlor, or 0.5 pint of 40 percent tetraethyl pyrophosphate.

Cotton Leafworm

The cotton leafworm, Alabama argillacea (Hbn.), has been controlled successfully for many years by calcium arsenate, paris green, or lead arsenate. Dust and spray formulations of benzene hexachloride, toxaphene, a mixture of benzene hexachloride and DDT, or a micture of toxaphene and DDT are effective in controlling the cotton leafworm.

Cutworms

Cutworm outbreaks may develop in weeds or crops, especially legumes. Cutworms migrate to adjacent cotton or attack cotton planted on land previously in weeds or legumes.

Recommended control measures are thorough seed-bed preparation, elimination of weed host plants, and use of insecticides. If the need for insecticides to save the stand is to be avoided, allow at least three weeks to elapse between the time of plowing under an infested area and the subsequent seeding of the cotton crop. Toxaphene and toxaphene-DDT sprays applied at a rate of 2 to 3 pounds per acre, DDT spray at 1 to 1.5 pounds per acre, and dieldrin at 0.375 to 0.5 pound per acre are effective. Twenty percent toxaphene or 10 percent DDT dusts applied at rates of 10 to 15 pounds per acre will give satisfactory control. Poison baits containing paris green, sodium fluosilicate, or toxaphene have been found satisfactory. A poison bait consisting of 40 percent of cryolite and 60 percent of citrus meal gives effective control.

Fall Armyworm

The fall armyworm, Laphygma frugiperda (A. & S.), occasionally occurs in sufficient numbers to damage cotton. The following dusts have given good control: Toxaphene 20 percent at the rate of 10 to 15 pounds per acre, sufficient benzene hexachloride to give 3 percent of the gamma isomer plus 5 percent of DDT at the rate of 10 to 15 pounds per acre, chlordane 10 percent at the rate of 15 to 20 pounds per acre, or DDT 10 percent at the rate of 10 to 15 pounds per acre. A 5 percent DDT dust will control small worms. Toxaphene at the rate of 2.0 to 2.5 pounds per acre or DDT applied at the rate of 0.5 to 1.0 pound of the technical material per acre in sprays have given good control. Other insecticides that have been effective when applied as sprays are: Dieldrin 0.15 to 0.30 pound of technical material per acre; benzene hexachloride containing 0.40 to 0.60 pound of gamma isomer per acre; and aldrin 0.25 to 0.50 pound of technical material per acre. The results obtained from the above materials have varied in different states, therefore, local recommendations are advisable. (Also see Bollworms, p. 24.)

Garden Webworm

The garden webworm, Loxostege similalis (Guen.), may be controlled on cotton by dusts containing 5 percent of DDT plus sufficient benzene hexachloride to give 3 percent of the gamma isomer, 20 percent of toxaphene, or 10 percent of DDT. Good control of this insect may be obtained with toxaphene, toxaphene plus DDT, DDT, and dieldrin sprays. DDT has given better control in sprays than in dusts and is generally less effective than the other listed materials. Calcium arsenate may also be used to control the garden webworm, but heavy poundages are required and control is generally less satisfactory than with the new organic insecticides.

Grasshoppers

Several species of grasshoppers attack cotton, particularly Melanoplus differentialis (Thos.) and Schistocerca americana (Drury). The adults of S. americana hibernate and deposit their eggs in the fields, but most other species overwinter as eggs in untilled soil, in fence rows, sod waterways, around stumps, and in similar locations. The latter can best be controlled by early treatment of hatching beds before the grasshoppers migrate into the fields. Sprays or dusts containing aldrin, chlordane, dieldrin, toxaphene, or benzene hexachloride are rapidly replacing poison baits for grasshopper control in many areas. This is particularly true where grasshoppers must be controlled on lush or dense vegetation.

Benzene hexachloride sprays and dusts usually produce a spectacular kill of the grasshoppers in a few hours, but results have been erratic and residual effectiveness is limited to 1 or 2 days. Aldrin, chlordane, dieldrin, and toxaphene are very effective but slower in their action. They remain residually effective for 5 to 14 days, however, depending on prevailing environmental conditions.

Dosages suggested to control grasshoppers fall within the following ranges:

	Pounds per acre
Aldrin	0.1 - 0.25
Benzene hexachloride, gamma isomer	0.3 - 0.5
Chlordane	0.5 - 1.5
Dieldrin	0.07 - 0.125
Toxaphene	1.0 - 2.5

The lowest dosage rates suggested are effective against newly hatched to half-grown grasshoppers. The dosage should be increased as the grasshoppers mature or when the materials are applied on partly defoliated plants or on plants unpalatable to the insects.

Baits made according to State and Federal recommendations still have a place in grasshopper control where treatment of extensive areas is required, particularly in sparse vegetation.

Pink Bollworm

Methods of controlling the pink bollworm, Pectinophora gossypiella (Saund.), include destruction of cotton stalks immediately after harvest, heat treatment of cottonseed, burning of gin waste, compression of lint, and the application of insecticides in dusts or sprays. In South Texas pink bollworm infestations early in any season are in proportion to the number of these insects that survive the period between crops. The longer this between crop period, the fewer the insects that survive. Therefore, the number of overwintering insects are reduced by destroying cotton stalks at the earliest possible date. The best procedure is to cut the stalks with one of the new type rotary shredders. These machines kill a considerable percentage of the pink bollworms during shredding operation. They shatter and spread the bolls on the ground so evenly that a higher kill is obtained by action of the sun, when temperatures are high, and this also permits a more thorough coverage of the residue during plowing operation. The roots should be plowed out promptly and the crop debris plowed under. All seedlings or sprouted cotton plants developing after the plowing should be eliminated before fruiting to create a long, host-free, period between crops. For best results, these cultural practices should be carried out on an area-wide basis and the cooperation of every cotton grower is needed. Cultural practices used to control the pink bollworm will also control the boll weevil.

Cotton growers of the Lower Rio Grande Valley of Texas have used the cultural method of control outlined. Over a 5-year period, lint production averaged 342 pounds per acre. Over a 5-year period prior to the beginning of control by early stalk destruction, lint production there averaged 213 pounds per acre. This increase in yield at prices prevailing during 1950 harvest amounted to around $17,000,000 for the 1950 crop from about 375,000 acres.

This increased production resulted largely through prevention of damage by pink bollworm, effective boll weevil control, and greater productivity of the soil because of improved farming methods. Weather conditions during 2 of the past 3 seasons, however, prevented compliance with the planting and stalk destruction practices required for pink bollworm control. Damage by the pink bollworm is increasing rapidly. Far greater quantities of insecticides are required now to control the boll weevil. It is expected that for the first time in South Texas, and the Lower Rio Grande Valley, large quantities of DDT will be required to prevent excessive pink bollworm damage in those areas in 1952.

There is a progressive build-up in the pink bollworm population as the season advances. Therefore, every effort should be made to expedite fruiting and setting the crop. The following practices are recommended for hastening the maturity of the cotton and thereby reducing pink bollworm infestation: Heat or chemical treatment of planting seed, early uniform planting of quick-maturing varieties, control of cotton fleahoppers, thrips, aphids, and other insects that delay fruiting, clean cultivation, elimination of late irrigation, and chemical defoliation.

In cold, arid regions, such as the West Texas Area where harvest must be completed after frost, as many bolls as possible should be removed by snapping, mechanical harvesting, or by heavy pasturing. The cotton stalks should be left standing during the winter months, since the highest mortality of hibernating pink bollworm larvae in such areas is obtained in bolls on standing stalks. Where the stalks are plowed under early in the winter the fields should be winter irrigated wherever possible.

Larvae of the pink bollworm enter mature cottonseeds to feed and hibernate. To prevent the overwintering or spread of the insect, cottonseed are given a heat treatment as a continuous process of ginning in much of the pink bollworm quarantined area. In the remainder of the area, cottonseed are heat-treated upon arrival at designated oil mills or other treating plants. In the heavily infested areas a second heat treatment is required before the seed can be moved into other quarantined or free areas. In all pink bollworm quarantined areas, gin waste is destroyed promptly by burning, or heat-treated for use as a fertilizer, and all lint is compressed before it is moved into areas that are free of pink bollworm.

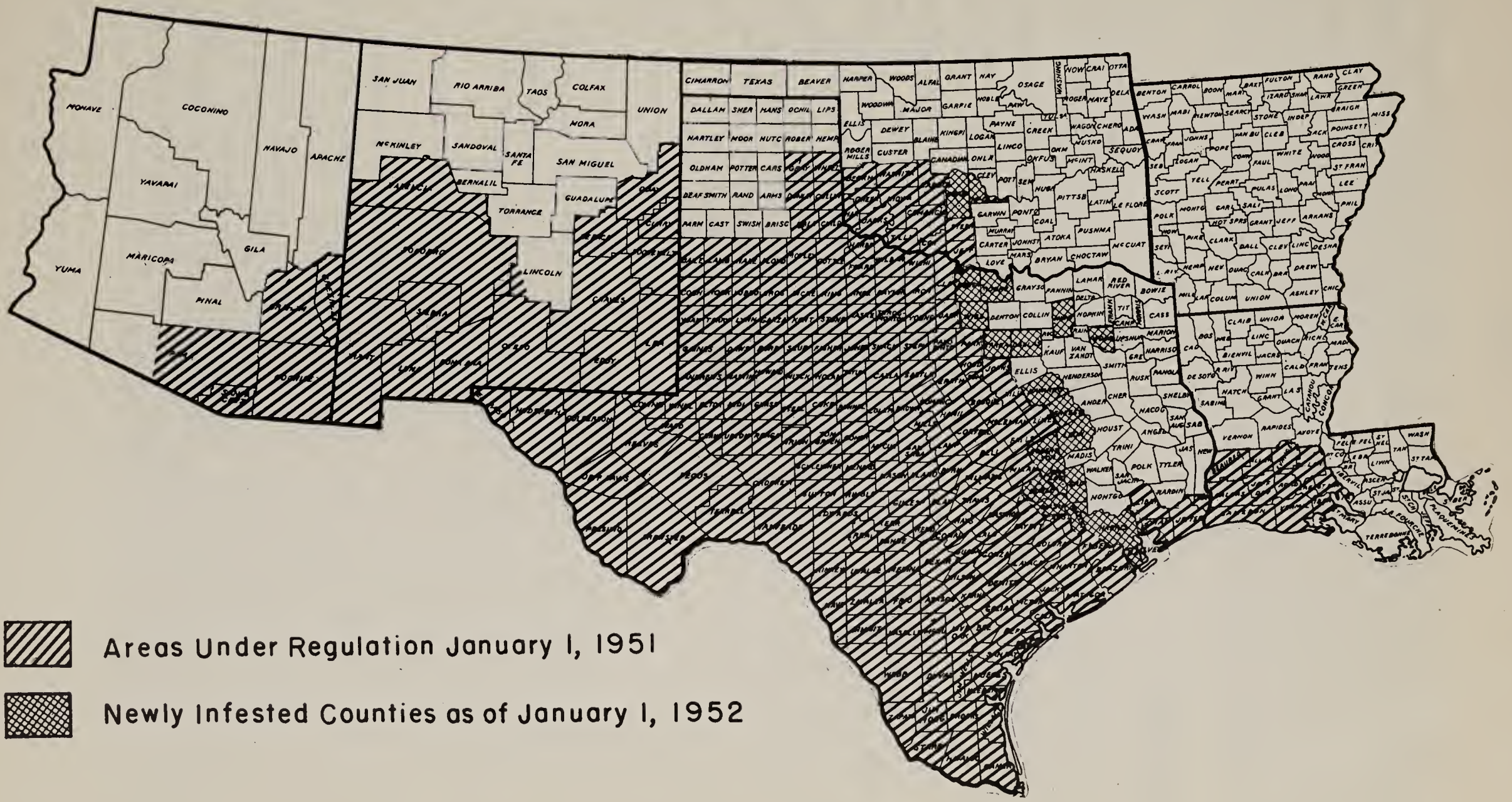
DDT is the best insecticide for control of the pink bollworm. It can be applied as a dust or as an emulsion spray. From 1.5 to 2 pounds of technical DDT should be applied per acre in each application. Dust formulations containing 10 percent of DDT should be applied at the rate of 15 pounds per acre. When control of the pink bollworm is essential to prevent damaging build-up and subsequent spread, it is recommended that not less than 2 pounds of technical DDT be applied at 7-day periods. Large-scale demonstration tests, with applications beginning when the cotton is in the 6- to 8-leaf stage, have proved highly effective when followed with later applications as required by infestation conditions of pink bollworms and other insects. These early applications are especially beneficial in shortening the fruiting period. The result is that fewer generations of pink bollworm develop and early stalk destruction is possible. The number of hibernating pink bollworms is thus reduced.

Aphids and spider mites may develop when DDT is used alone for pink bollworm control. Benzene hexachloride and sulfur, or parathion, may be added to the dust formulations and TEPP may be added to the spray formulations for control of these pests.

Regardless of the other insects to be controlled, all formulations for control of the pink bollworm should contain sufficient DDT to give the

PINK BOLLWORM REGULATED AREAS

JANUARY 1, 1952



minimum of 1.5 pounds of technical DDT per application per acre irrespective of the other materials or the spacing of applications.

The accompanying map shows the areas under quarantine because of the pink bollworm. Farmers, county agents, ginners, and all others in the cotton industry should cooperate fully with State and Federal quarantine agencies in preventing spread of the pink bollworm, especially with regard to the movement of cottonseed from infested areas.

Spider Mites

Several species of spider mites are known to attack cotton, including the two-spotted spider mite, Tetranychus bimaculatus Harvey, and a recently described species, Septanychus texazona McG.

It is known that the use of certain of the organic insecticides for cotton insect control has resulted in serious spider mite infestations.

Sulfur, at the rate of 20 to 25 pounds per acre, has been the standard recommendation for the control of spider mites for many years. Satisfactory results have usually been obtained from its use. Organic insecticide dusts for use on cotton have been formulated in some areas to contain at least 40 percent of properly conditioned dusting sulfur. The use of such formulations has usually prevented damage from spider mites.

Other satisfactory miticides have been developed during recent years. Some of these synthetic substitutes were widely tested and used in 1951.

Since sulfur is now in critically short supply and since satisfactory substitutes are now available, it is recommended that sulfur be deleted from the local recommendations for control of cotton pests when feasible to do so.

Parathion applied as a dust or spray at the rate of 0.10 to 0.25 pound per acre is highly effective against spider mites on cotton.

TEPP at the rate of 0.5 pint of the 40 percent concentrate, or its equivalent, per acre, effectively controls heavy populations. Its effectiveness, however, is of short duration.

Aramite applied at a rate of 0.3 to 0.6 pound per acre gives good control of spider mites.

Several organic sulfur compounds are known to be more or less effective for spider mite control. These include sulfones, sulfites, and sulfonic acid compounds. Erratic results have resulted from the use of these compounds and they are not yet generally recommended.

Elemental sulfur cannot be incorporated in spray formulations when the organic insecticides are applied as low-gallonage sprays. When sprays are being used, and mite populations begin to increase noticeably, aramite, parathion, or TEPP at the above dosages may be added to the next spray application for mite control.

Other compounds tested under field conditions during 1951 which appear sufficiently promising to justify recommendation for experimental use during 1952 are as follows:

1. EPN at a rate of 0.3 pound or more per acre.
2. Octamethyl pyrophosphoramide at 0.5 to 1 pound per acre.
3. Systox at 0.25 to 0.5 pound per acre.

Further experimental work on methyl ester of parathion, metacide, and compound 4049 at 0.25 pound or more per acre is justified.

S. texazona is more susceptible to certain miticides than T. bimaculatus. It may be necessary to increase the amounts of the chemicals mentioned where the latter species occurs.

Spider mites overwinter on low-growing perennials. These can be destroyed by winter cultivation, giving particular attention to normally uncultivated spots around stumps and along margins of fields. Such practices aid in controlling outbreaks.

Tarnished Plant Bug, Rapid Plant Bug, and Related Species

The tarnished plant bug, Lygus oblineatus (Say), the rapid plant bug, Adelphocoris rapidus (Say), and related species such as Creontiades debilis (Van D.) and Neurocolpus nubilus (Say) often cause injury to cotton. The organic insecticides recommended for boll weevil or bollworm control are effective against these plant bugs.

Thrips

Thrips often cause more injury to cotton seedlings than generally realized, especially in areas where onions, legumes, and small grains are grown extensively. The destruction of leaf tissue by thrips, and subsequent slow plant growth, make the seedlings more susceptible to injury by diseases. Injury by thrips alone, or the combined injury of thrips and disease, may reduce or even destroy stands of young plants. A heavy infestation often retards plant growth and delays fruiting and crop maturity. This delay in crop maturity may increase the cost of harvest and may lower the quality of seed and lint because of the greater damage by insects and deterioration associated with unfavorable weather conditions.

A number of properly applied insecticides give satisfactory thrips control. Toxaphene at the rate of 0.5 to 1 pound per acre, in either dust or spray form, gives effective control. A spray mixture consisting of 0.5 pound of toxaphene and 0.25 pound of DDT per acre, or a dust or spray mixture of DDT and benzene hexachloride applied at a rate of 0.15 pound of gamma isomer plus 0.25 pound of DDT, per acre is also effective.

Heptachlor or aldrin applied to young seedlings as a spray or dust at the rate of 0.08 to 0.125 pound per acre gives good thrips control. Dieldrin applied at the rate of 0.05 to 0.1 pound per acre is very effective.

Other insecticides which give satisfactory control either as a spray or a dust are chlordane at 0.5 to 1 pound per acre, benzene hexachloride 0.1 to 0.15 pound of gamma isomer, and DDT 0.25 to 0.5 pound. DDT has not given satisfactory control at temperatures above 90° F.

Some of the phosphate compounds are effective against thrips, but are not generally recommended for the control of thrips because of their extremely poisonous nature.

Tobacco Budworm

See Bollworms, p. 24.

White-Fringed Beetles

The white-fringed beetles, Graphognathus leucoloma (Boh.), G. peregrinus (Buch.), and G. minor (Buch.), are pests of cotton and many other farm crops. These insects are present in limited areas of Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee.

Larvae of the white-fringed beetles damage cotton by feeding on the roots of young plants. These insects can be controlled by the use of good cultural practices and insecticides. Good cultural practices recommended include the following:

1. Plant oats or other small grains in heavily infested areas.
2. Restrict planting of summer legumes, such as peanuts, soybeans, velvet beans, or other favorable host plants of the adult beetles to not more than one-fourth of the total crop land. Do not plant these crops on the same land more often than once in 3 or 4 years.
3. Do not intercrop corn with peanuts, soybeans, crotalaria, or velvet beans. Prevent the growth of broadleaved weeds, such as cocklebur and sicklepod.
4. Improve poorer soils by turning under winter cover crops.

DDT is effective for control of white-fringed beetle larvae. Apply 50 percent DDT at the rate of 20 pounds per acre, or 25 percent DDT at the rate of 40 pounds per acre, evenly to the soil surface as a dust, spray, or mixed with sand. Thoroughly mix it into the upper 3 to 4 inches of soil. This treatment will give control of larvae for at least 5 years. DDT may be used in the drill before planting. Use 50 percent DDT at the rate of 5 to 10 pounds per acre, or 25 percent DDT at the rate of 10 to 20 pounds per acre, mixed with sand. This may be applied by hand or by a fertilizer distributor, at or slightly below the depth of seed planting.

Either toxaphene or a benzene hexachloride-DDT mixture applied on cotton foliage gives a residue in the soil which aids in the control of white-fringed beetles. These insecticides should be used for the control of those cotton insects for which they are recommended in white-fringed beetle infested areas.

Wireworms

Several species of wireworms are associated with cotton. Perhaps most noticeable damage is caused by the sand wireworm, Horistonotus uhlerii Horn., in South Carolina, Louisiana, and Arkansas. Adults of the tobacco wireworm (spotted click beetle), Conoderus vespertinus (F.), are frequently found on the cotton plant, but the amount of damage to cotton caused by the larvae of this species is not known.

Approved crop rotation practices, increased soil fertility, and added humus, help to reduce damage to cotton caused by the sand wireworm. Chlordane, DDT, lindane, and benzene hexachloride have shown promise in the control of this and other species of wireworms on other crops. Additional research on the control of wireworms attacking cotton is needed.

Yellow-Striped Armyworm

The yellow-striped armyworm, Prodenia ornithogalli Guen., occurred in large numbers over a large portion of the Cotton Belt in 1951 for the first time in many years. It did considerable damage in some areas. This insect proved the most difficult of all the "Bollworms" to kill with organic insecticides. EPN (O-ethyl O-p-nitrophenyl benzenethiophosphonate) at 0.3 pound per acre applied as an emulsion spray was superior to any of the chlorinated hydrocarbons. However, when used in the early stages of worm development, toxaphene at 2.5 pounds per acre, DDT at 1 pound, and dieldrin at 0.3 pound in an emulsion spray gave fair control. Dieldrin in a 3-percent dust and toxaphene in a 20-percent dust applied at the rate of 15 pounds per acre also gave relatively good kills of a mixed population of large and small yellow-striped armyworms.

Miscellaneous Insects

Cabbage looper, Trichoplusia ni (Hbn.): The cabbage looper and several other closely related species occasionally cause damage to cotton in localized areas. Dusts containing 5 percent of DDT or 10 percent of toxaphene, applied at the rate of 10 pounds per acre, or sprays containing toxaphene or DDT applied at the rate of 1 pound and 0.5 pound per acre, respectively, are effective.

Corn silk beetle, Luperodes brunneus (Crotch): This insect has been reported as a pest of cotton in localized areas in several States but little is known about it.

Cotton root aphids: The species of root aphids known to attack cotton are the corn root aphid, Anuraphis maidi-radicis (Forbes); Triphidaphis phaseoli (Pass.); and Rhopalosiphum subterraneum Mason. So far as is known, injury by root aphids to cotton is confined to the Eastern Seaboard. Several species of ants are known to be associated with root aphids, the principal one being the cornfield ant, Lasius niger alienus americanus Emery. Chemical control of root aphids has been directed at control of the cornfield ant. Some of the newer materials are known to be effective as soil insecticides, and it is suggested that they be tested against root aphids attacking cotton. Root aphids injure cotton chiefly in the seedling stage. Since cotton in this stage often shows signs of injury without any evidence of insects being present, it is suggested that careful examinations be made of the underground portions to determine the possibility of root aphid attack. Ant mounds at the base of seedling plants indicate the presence of root aphids.

Cotton square borer, Strymon melinus (Hbn.): The cotton square borer occurs throughout the Cotton Belt, but rarely causes economic damage. The injury caused by the insect to squares is often attributed to the bollworm.

Cotton stainer, Dysdercus suturellus (H.-S.): The cotton stainer occurs within the continental limits of the United States in Florida only. However, probably due to mistaken identity, the literature also records it from Alabama, Georgia, and South Carolina. No work has been formally reported in recent years on control, but observations indicate that dusts containing 10 percent of toxaphene or sufficient benzene hexachloride to give 1 percent of the gamma isomer will control insects of this genus. There are indications that DDT may also be effective in some areas.

Cowpea aphid, Aphis medicaginis Koch: The cowpea aphid occurs commonly on very young cotton, especially on the cotyledonous leaves. Cotton is not believed to be a true host of this species and the insect will not complete a life cycle on the cotton seedling.

Darkling beetles: These insects damage young cotton in some areas. They can be controlled with 5-percent chlordane dust applied at the rate of 20 pounds per acre, or with toxaphene, DDT, or a toxaphene-DDT 2 to 1 mixture applied as sprays at the rate of 1 to 2 pounds of technical material per acre.

Flea beetles: These insects are serious pests of cotton in some areas. The same insecticides recommended for thrips control will control flea beetles.

Grape colaspis, Colaspis flavida (Say): Calcium arsenate and DDT have given satisfactory control of this insect on cotton.

Salt-march caterpillar, Estigmene acrea (Drury): The salt-marsh caterpillar can be controlled with toxaphene applied as either a dust or a spray at the rate of 3 pounds of technical material per acre, preferably when worms are small.

Insects That Attack Cottonseed in Storage

Cottonseed rarely becomes infested with insects while in storage when proper precautions are followed. Cottonseed or seed cotton should be stored only in a bin or room thoroughly cleaned of all old cottonseed, grain, hay, or other similar products in which insects that attack stored products are likely to develop. Among the insects that cause damage to stored cottonseed or to cottonseed meal are the cigarette beetle, Lasioderma serricorne (F.), the Mediterranean flour moth, Ephestia kühniella Zell., and the Indian-meal moth, Plodia interpunctella (Hbn.). Cottonseed that is to be used for planting only may be dusted with toxaphene before being placed in storage. Seed so treated should not be crushed or used for feed.

Parasites and Predators of Cotton Insects

Parasites and predators aid greatly in the control of insect pests of cotton. However, their help cannot always be relied upon and it is usually necessary to use cultural control practices and to spray or dust the cotton with insecticides. Extensive investigations, which have included the importation and colonization in cotton fields of several insect parasites of the pink bollworm, have shown that so far the use of these natural enemies of cotton insects has limitations.

Cotton Insect Surveys

The importance of surveys to an over-all cotton insect control program has been clearly demonstrated during the last few years. Cotton insect surveys conducted on a cooperative basis by State and Federal agencies in most of the major cotton-growing States have developed into a broad, currently advisory service for the guidance of the farmer, others associated with cotton production, and the industry that serves the farmers by supplying insecticidal chemicals. As a result of survey work, farmers are forewarned of the insect situation and losses are materially reduced below what they would be without the information thus gained. The survey also helps to direct insecticides to areas where supplies are critically needed.

More people are being employed each year by business firms, individual farm operators, and others interested in cotton production to determine cotton insect populations. It is important that individuals

employed by private interests to make surveys understand the control programs as well as how to make infestation counts. Therefore, State and Federal entomologists should assist in locating personnel that have at least some basic training in entomology to do survey work for private interests. If this is not done, many growers are sure to be misinformed about recommended control practices.

Information obtained through surveys on insect populations has done much to create interest in cotton insect control programs. When survey data are collected, interpreted, and disseminated at weekly intervals, it is helpful to growers, the insecticide industry, entomologists, and all others interested in an effective control program. The extent and intensity of coverage largely determines the value of surveys. It is the type of service that can be supplied only through leadership and cooperative undertaking. Therefore, it is recommended that cotton insect surveys be continued, that they be placed on a permanent basis, and that they be expanded to include all cotton-producing States.

Whereever possible, it is well to enlist and train voluntary cooperators to make field observations and records and to submit reports during the active season. Wider dissemination of the information that is compiled is highly desirable.

Extension Educational Programs for 1952

There is a serious need for a strong educational program that will present the facts concerning cotton insect control. This program should be conducted in such a way that everyone interested in cotton production will be reached. Growers especially need these facts to help them in making plans for 1952.

In order that cotton growers may follow the recommendations made by the State and Federal entomologists without confusion, such recommendations must be basically the same in areas where the insect problems are similar. Points upon which agreement must be reached are: (1) Insecticides that are effective, economical, and safe to use with proper precautions, (2) time to start treatment, (3) rate of application, (4) interval between applications, and (5) how to apply the insecticides. Confusion will seriously interfere with effective insect control if these points are not agreed upon.

To facilitate the production of the required 1952 crop of cotton, the Extension Service will immediately strengthen and intensify its educational work on the seven-step cotton-production program. To help accomplish the goal each State should have the following committees: (1) A State-wide cotton production committee made up of representatives from all agencies and organized groups within the State to help develop, promote, and provide leadership to the program; (2) a technical committee made up of representatives from all State and Federal agricultural agencies to prepare

recommendations on cotton production and insect control; (3) an extension committee selected by the State Director, which will be responsible for the educational program. Each county or parish should be organized on a basis somewhat comparable to that of the State.

Experience has shown that committees such as those outlined above play an important part in the planning and carrying out of an integrated program in which all agencies and segments of industry can cooperate. As a result of the cooperative effort, growers will be kept informed of the need for insect control and industry will know better the need for insecticides.

The following steps listed on a seasonal basis outline the extension program that will be carried out in varying degrees in the Cotton States:

Winter

A. State or area meetings with insecticide suppliers and applicators.
B. District meetings with county agents and farm leaders.
C. General county (parish) meetings, stressing early purchase and farm storage of insecticides and equipment.
D. Preparing and issuing radio and newspaper releases, circular letters, and posters on early purchase and farm storage of insecticides and equipment.
E. Securing of cooperation with the farm loan agencies, oil mills, ginners, fertilizer associations, and other groups concerned with the production of cotton.

Spring

A. Surveys by State and Federal entomologists to determine boll weevil survival.
B. Continuation of meetings on cotton insect control. Giving of information on the survival of boll weevils and the control recommendations.
C. Newspaper and radio releases on boll weevil survival.
D. Demonstrations on procedure for making boll weevil counts per acre in order to determine when and where early boll weevil control is needed.
E. Counts of boll weevils per acre on seedling cotton.
F. Recommendations on early season control of boll weevils, thrips, and other cotton insects.
G. At least one 4-H Club meeting devoted to cotton insects and their control.

Summer

A. Square infestation counts by State and Federal entomologists, county agents, and community workers.
B. Field demonstrations on insect identification, infestation counts, and proper application of insecticides.
C. Timely radio programs, newspaper articles, and circular letters on insect conditions and control.
D. Field tours to study demonstrations and experiments on cotton insect control.
E. Daily radio reports on weather conditions.

Fall

A. Stressing of importance of defoliation in preventing insect damage to young bolls.
B. Promoting an early stalk destruction program to reduce insect populations.

Full use should be made of the following educational tools to stimulate the adoption of recommended practices:

1. Publications--yearly recommendations.
   a. Plan of organizational set-up showing responsibility of each agency.
   b. Yearly recommendations for insect and disease control.
2. Mimeographed informational material.
3. Posters, charts, exhibits at fairs, models.
4. Magazine articles.
5. Cotton letter or other circular letters.
6. Newspaper publicity, special editions.
7. Radio spot announcements and recordings. Sponsored program at set time and day each week so as to build up a listening audience for the program.
8. Public meetings.
9. Individual contacts.
10. Slides and motion pictures.
11. Television where available.
12. Equipment displays at method demonstrations.
13. Result demonstrations.
14. Visits to Experiment Stations.

Needed Research

Additional information is needed on the following subjects:

1. Spray formulations for use in the control of cotton insects.
   a. Solvents and emulsifiers.
   b. Re-evaluation of toxicants and mixtures of toxicants.

2. Designs of machinery and equipment for applying sprays and dusts, including aircraft particularly adapted to various agricultural needs.
3. The value of community action in controlling cotton insects.
4. The physiological and phytotoxic reaction of insecticides to plants.
5. The interrelationship between vegetation and fruiting of the cotton plant, with special reference to the timing of insecticide applications.

Basic information is needed on the following subjects:

1. The comparative toxicity of different insecticides and combinations.
2. Defoliation in relation to the control of cotton insects.
3. The effect of early-season infestations on the subsequent development and yield of cotton.
4. The physiological mode of action of insecticides on insects.
5. The effect of sublethal dosages of insecticides upon insect reproduction and development.
6. The effect of temperature, humidity, sunlight, rainfall, and air currents upon the effectiveness of insecticides.
7. Improved techniques for testing insecticides.
8. The effects of insecticides upon natural enemies of cotton insects.
9. The effects of insecticides applied to cotton upon soils and subsequent crops.
10. The effect of insecticides upon livestock, poultry, wild life, and man.
11. The possibility of contamination of food products by organic insecticides applied for the control of cotton insects.
12. The possibility of the development of insect resistance to insecticides.
13. Factors influencing the deterioration of insecticides in storage.
14. The effects of insecticides on honey bees and other pollinating insects.
15. The relation of factors, such as coverage, particle size, distribution, adherence, and residual toxicity of insecticides, to cotton insect control.
16. The effect of ecological factors, cropping systems, natural enemies, cultural practices, and plant nutrition upon cotton insect populations.
17. Combining insect control with other operations in mechanized production of cotton.
18. The seasonal development, life histories, and habits of the major cotton pests and others that are potentially injurious.
19. Possible insect vectors of cotton diseases.

Conferees at the Second Memphis, Tennessee Conference

Entomologists and associated technical workers concerned with cotton insect research and control from the Agricultural Experiment Stations, Extension Services, and other State agencies in thirteen cotton-growing States, the United States Department of Agriculture, and the National Cotton Council of America participated in the Cotton Insect Research and Control Conference held at the Gayoso Hotel, Memphis, Tenn., December 2, 3, and 4, 1951. All statements in this report were agreed upon and adopted by the conferees listed below:

Alabama

F. S. Arant, Head, Zoology-Entomology, A. P. I., Auburn

Arkansas

Charles Lincoln, Head, Ent. Dept., Univ. of Arkansas, Fayetteville
Gordon Barnes, Extension Entomologist, Univ. of Arkansas, Fayetteville
Francis J. Williams, Research Entomologist, Cotton Expt. Sta., Marianna

Florida

J. W. Wilson, Entomologist, Central Fla. Expt. Sta., Sanford

Georgia

C. M. Beckham, Entomologist, Ga. Agr. Expt. Sta., Experiment
Loy W. Morgan, Asst. Entomologist, Ga. Coastal Expt. Sta., Tifton

Louisiana

C. E. Smith, Entomologist, Agr. Expt. Sta, L. S. U., Baton Rouge
L. D. Newsom, Asst. Entomologist, Agr. Expt. Sta., L. S. U., Baton Rouge
John S. Roussel, Asst. Entomologist, Agr. Expt. Sta., L. S. U., Baton Rouge
K. L. Cockerham, Extension Entomologist, L. S. U., Baton Rouge

Mississippi

Clay Lyle, Dean and Director, Agricultural Division, State College
R. E. Hutchins, Head, Zoology and Entomology, State College
L. C. Murphree, Extension Entomologist, State College
R. E. Furr, Assistant Entomologist, Stoneville
T. M. Waller, Agronomist, Extension Service, State College
B. J. Young, Vice President, Delta & Pine Land Co., Scott
A. G. Barrett, Department of Entomology, State College
H. S. Johnson, Jr., Department of Entomology, State College
J. R. King, Department of Entomology, State College
L. O. Sanchez, Department of Entomology, State College

Missouri

V. F. Burk, Extension Entomologist, Univ. of Missouri, Columbia

North Carolina

George D. Jones, In Charge, Ext. Ent., N. C. State College, Raleigh
R. T. Gast, Asst. Research Professor, N. C. State College, Raleigh
J. A. Shanklin, Extension Cotton Specialist, N. C. State College, Raleigh
R. L. Rabb, Extension Entomologist, N. C. State College, Raleigh

Oklahoma

F. A. Fenton, Head, Dept. Ent., Okla. A and M College, Stillwater
James R. Dogger, Dept. Ent., Okla. A and M College, Stillwater
Clyde A. Bower, Director, Div. Ent. & Plant Industry, State Dept. of Agr., Oklahoma City
C. F. Stiles, Ext. Ent., Okla. A and M College, Stillwater

South Carolina

M. D. Farrar, Head, Dept. Ent., Clemson Agr. College, Clemson
W. C. Nettles, Leader Ext. Ent. and Plant Disease Work, Clemson Agr. College, Clemson
J. G. Watts, Entomologist, Edisto Expt. Sta., Blackville
L. M. Sparks, Jr., Extension Entomologist, Clemson

Tennessee

W. W. Stanley, Entomologist, Agr. Expt. Sta., Knoxville
R. P. Mullett, Extension Entomologist, Univ. of Tennessee, Knoxville
Arthur P. Morris, Entomologist, State Dept. of Agr., Nashville

Texas

H. G. Johnston, Head, Dept. of Ent., Texas A and M College, College Station
J. C. Gaines, Entomologist, Agr. Expt. Sta., College Station
A. C. Gunter, Extension Entomologist, Texas A and M College, College Station
G. P. Wene, Entomologist, Texas Agr. Expt. Sta., Weslaco
A. N. White, Associate County Agent-Entomologist, Weslaco
C. R. Jordan, Ent. Dept., Texas A and M College, College Station
M. E. Merkl, Ent. Dept., Texas A and M College, College Station

Virginia

J. O. Rowell, Extension Entomologist, V. P. I., Blacksburg

United States Department of Agriculture

Agricultural Research Administration

Bureau of Entomology and Plant Quarantine

F. C. Bishopp, Assistant Chief, Washington, D. C.
David G. Hall, Div. of Insect Survey and Info., Washington, D. C.
L. F. Curl, Regional Director, PO Box 2300, San Antonio, Texas
R. W. Harned, Div. of Cotton Insects, Washington, D. C.
R. C. Gaines, Div. of Cotton Insects, Tallulah, La.
K. P. Ewing, Div. of Cotton Insects, Waco, Texas
C. R. Parencia, Jr. Div. of Cotton Insects, Waco, Texas
A. J. Chapman, Division of Cotton Insects, Brownsville, Texas
C. F. Rainwater, Div. of Cotton Insects, College Station, Texas
E. W. Dunnam, Div. of Cotton Insects, Stoneville, Miss.
S. L. Calhoun, Div. of Cotton Insects, Stoneville, Miss.
L. C. Fife, Div. of Cotton Insects, Florence, S. C.

Bureau of Plant Industry, Soils, and Agricultural Engineering

W. H. Tharp, Asst. Leader, Cotton Div., Beltsville, Md.
H. R. Carns, Plant Physiologist, Cotton Div., Stoneville, Miss.
J. E. Hite, Agronomist, Cotton Div., Jackson, Miss.

Office of Experiment Stations

E. R. McGovran, Entomologist, Washington, D. C.

United States Department of Agriculture--Continued

Extension Service

M. P. Jones, Entomologist, Washington, D.C.

Production and Marketing Administration

Harold H. Shepard, Office of Materials and Facilities, Washington, D. C.

National Cotton Council of America, Memphis, Tennessee

Claude L. Welch, Director, Division of Production and Marketing
J. Ritchie Smith, Head, Educational Services, Prod. and Marketing Div.
Hal C. Dilworth, Educational Specialist
Jack F. Criswell, Educational Specialist
Bill Foreman, Office of Public Relations
Charlie W. Jones, Economic Analyst

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